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DEPARTMENT OF COMMERCE – BUREAU OF MINES

SAFEGUARDING ELECTRICAL EQUIPMENT USED IN GASSY MINES

EUROPEAN PRACTICE: II - BELGIUM

BY

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By L. C. Ilsley[2]

INTRODUCTION

Cooperation between the United States Bureau of Mines and the Safety in Mines Research Board of Great Britain, continuous since 1924, has made possible this and other papers on safety subjects. Grateful acknowledgment is made to representatives of the Safety in Mines Research Board of the Mines Department for their assistance in arranging visits to several mine safety stations, and to F. R. Wynne, Deputy Chief Inspector of Mines, Great Britain, for arranging visits to mines in Great Britain, Belgium, Germany, and France.

During the summer of 1927 the writer had the privilege of visiting the mine safety testing stations in Great Britain, Belgium, Germany, and France, in the order named. All of these countries have large coal mines, many of which are rated as gassy. Therefore, when installation of electrical equipment is contemplated, each of these countries is confronted with the same safety problem as is the United States - the development of electrical equipment that will not ignite gassy mine atmospheres which might, through neglect or accident surround the equipment. The means used by these countries in safeguarding gassy mines should therefore be of general interest to safety engineers of American coal mines, and it is proposed to give a brief survey for each of the four countries mentioned. This paper presents the second of these surveys, which covers conditions in Belgium.

CONDITIONS IN BELGIUM

The first paper of the series on electrical equipment in Europe outlined conditions pertaining to coal mines in Great Britain. This second paper gives a similar study of electrical safety work connected with Belgian mining.

As yet Belgian companies have not installed a large amount of electrical equipment in mines, but undoubtedly such equipment will be increased from year to year. However, in the case of gassy mines electrical installations will undoubtedly be under rigid regulations.

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Some of the Belgian mines are notably "fiery," and others are subject to instantaneous outbursts of gas; hence that country, for self-protection, has for a great many years given safety engineering a prominent place in its mining work, and consequently the electrical regulations should be of real interest to those confronted with similar dangerous conditions.

CLASSIFICATION OF MINES

In order to have a clearer picture of Belgian mining conditions it is necessary to note their scheme for classifying coal mines. This scheme, which at first may seem complicated, is based on principles of safety, and it would be wel if more mining men would think of the possible dangers of their mines from a like angle. The classification follows:

1. From point of view of fire damp:
    - (a) Nongassy mines.
    - (b) Gassy mines.
        - (1) Slightly gassy.
        - (2) Gassy.
        - (3) Mines subject to instantaneous outbursts.
2. From point of view of dust:
    - (a) In nongassy mines, seams of coal containing from 15 to 22 per cent volatile matter (ash free), and in which the brushing of the sides of the roadways puts carbonaceous dust into suspension in the atmosphere, come, as regards regulations applicable to explosives, under, the rules applicable to mines classified in category b (1), that is, slightly gassy.
    - (b) In nongassy mines and in mines coming under b (1) owing to fire damp content, the seams of coal containing more than 22 per cent volatile matter (ash free), and in which the clearing of the sides of the roadways puts coal-dust in suspension in the atmosphere, come under the rules applicable to mines classified in category b, (2) that is, gassy.

Nevertheless, if it is established that certain beds give rise to dust which is not dangerous on account of its physical state, classification of the beds under category b (1) can be demanded.

3. The classification of seams of coal can be made for each district or group of districts by the Divisional Inspector of Mines. The classification can be modified at any time. Samples of dust will be collected by the Inspector of Mines and the analysis made by the Mines Department at the expense of the owner.

In mines where naked lights are allowed, it is understood that open-type motors and accessories have been permitted if provided with protective covers. In gassy and slightly gassy mines, approved electrical equipment has been allowed. In mines subject to instantaneous outbursts of gas, no electrical apparatus has been permitted.

TENTATIVE REQUIREMENTS FOR EXPLOSION-PROOF ENCLOSURES

In a pamphlet entitled "Reports on the Problems of the National Institute of Mines at Frameries During the Year 1926," there is included a tentative schedule of requirements for explosion-proof electrical equipment and an outline of the test procedure by M. Emanuel Lemaire, Deputy Director. A free rendering of this schedule follows:

> First there is an introduction to the effect that numerous flameproof types of electrical equipment were tested in gas during 1926. Following these tests, a tentative set of rules to be observed in the manufacture and use of this equipment was drawn up. These rules were not final. They were drawn up to serve as a basis for the exchange of ideas with the manufacturers and users in order to arrive at a set of rules which would assure safety without undue severity on makers or users. The rules follow:

General

Every electrical apparatus whose own circuits (or those circuits of which it forms a part) include windings is considered to be capable of producing dangerous sparks either as a result of normal operation or through accident.

Consequently all apparatus of this kind which is intended to be used in a place where the possible presence of fire damp is to be feared, must be surrounded with an "explosion-proof" enclosure.

Explosion-proof Enclosures

Under this heading are three types - hermetically sealed enclosures, enclosures with protected openings and enclosures with open joints.

A. Hermetically sealed enclosures.

1. Enclosures with an interior volume greater than 2 liters (0.07 cubic foot) must be able to withstand an internal pressure of 8 kilograms per square centimeter (112.76 pounds per square inch.)

2. Enclosures with an interior volume less than 2 liters must be able to withstand an internal pressure of 6 kilograms per square centimeter (85.3 pounds per square inch.)

B. Enclosures with protected openings.

1. Enclosures with protected opening must be able to withstand the pressure developed by the explosion of a fire damp mixture containing 10 per cent methane.

2. The openings in the enclosure must be protected by building up layers of rigid nonoxidizable metal, not less than 50 millimeters (1.97 inches) in width and not less than 0.5 millimeter (0.02 inch) thick, held apart at a maximum distance of 0.5 millimeter (0.02 inch) by means of spacers running the full width of the layers, and spaced close enough so that the distance between layers can not exceed 0.5 millimeter (0.02 inch) if the layers themselves should be bent.

3. The protective devices must be protected against injury and deterioration.

4. The diaphragms of telephone transmitters and receivers shall be protected by a metallic gauze of nonoxidizable material with a mesh of not less than 144 openings to the square centimeter.

C. Enclosures with open joints.

1. These enclosures must be able to withstand the pressure developed by the explosion of a fire damp mixture containing 10 per cent methane.

2. The depth of the opening in the joint can not exceed 0.5 millimeter (0.02 inch), and means must be provided to make any increase of this depth impossible.

3. The width of the open joint can not be less than 50 millimeters (1.97 inches.)

D. Additional methods.

Other methods of stopping flame can be considered allowable after investigation.

General Requirements

1. Assembling can be accomplished:

(a) By screw joints having at least two complete threads.

(b) With flat joints. The surfaces in contact must be machined. Their width must be at least 25 millimeters

(0.98 inch.) The distance between the inner edge of bolt or screw holes and the inside edge of the inclosure must be at least 10 millimeters (0.39 inch).

(c) With flat joints fitted one in the other. The depth of the part fitting into the other must be at least 10 millimeters (0.39 inch). The contact surfaces of the fitted joint must be machined and the clearance between these surfaces must not exceed 0.25 millimeter (0.01 inch).

2. Rubber, asbestos, or other materials of little mechanical strength are forbidden for use in joints except when used in the assembly of fitted-in joints.

3. Bolts, tapped holes, etc., must not pass from one side to the other of the walls of the compartment but must be embedded in sheaths or bottomed holes.

4. Bolts, screws, etc., holding the covers and various parts shall be furnished with devices which will allow them to be loosened only by the use of special wrenches.

5. Shafts, push buttons, etc., must pass through the walls of the enclosure in close-fitting metallic sheaths or bearings not less than 25 millimeters (0.98 inch) in length. The grease grooves must not form a path from the inside of the enclosure to the outside. They must be separated by at least 10 millimeters (0.39 inch), and if they are longitudinal there must be a break at least 10 millimeters (0.39 inch) long.

6. Motor shafts shall pass through the walls of the enclosure in metal bushings at least 50 millimeters long (1.97 inches) for straight bushings. Labyrinthine bushings may be permitted after investigation. The clearance between the shaft and the bushings shall not exceed 0.5 millimeter (0.02 inch). For motors whose air gap exceeds 0.5 millimeter (0.02 inch) the necessary steps must be taken to avoid friction of the shaft on the bushings. Grease cups must be outside the enclosure.

7. Connection of armored cables to the apparatus shall be made:

   1. In a box filled with insulating compound and fastened on the outside of the apparatus. The metal armor of the cable shall be securely attached to the box. The passage of the electric conductors through the wall of the enclosure shall be made through terminal posts firmly attached to the wall and insulated therefrom. On both sides of the wall the conductors shall be connected to the terminal posts by solder or by clamps with screws and lock nuts.

   2. By passing the cable through the wall of the enclosure in a stuffing box with metallic packing in accordance with the following conditions:

(a) The metal armor of the cable shall be firmly attached to the outside of the enclosure in a way that the armor itself shall take any strain to which the cable might be subjected.

(b) The lead sheathing of the cable shall be made bare where it goes through the stuffing box and also, if need be, shall be made cylindrical in shape.

(c) The metal packing of the stuffing box shall be at least 12 millimeters (0.47 inch) long when compressed. The gland nut or gland shall engage in the stuffing box either by screw threads with at least two complete threads engaged or by a fitted joint. The depth of joint or engagement of the parts shall be at least 12 millimeters (0.47) after the packing is compressed.

8. The connection of flexible cables to apparatus must be made in a manner similar to those means prescribed for the armored cables, and to means approved after investigation.

9. The peepholes in the walls of the enclosure shall be protected by a double-thickness glass window solidly set in the walls.

10. Connection to the current supply by means of plugs shall be made as follows:

(a) The socket shall end in a metallic sheath in which is fitted a piece of metal shaped like the plug. At the instant the conducting parts come into contact, the depth of the joint shall be not less than 50 millimeters (1.97 inches). The clearance between the contact surfaces of the joint can not exceed 0.25 millimeter (0.01 inch).

(b) A locking device shall prevent making the socket or plug alive before all parts are assembled and manipulating them when they are alive.

Tests

Each type of apparatus submitted for investigation by the National Institute of Mines shall be submitted to a test consisting of causing an explosion of a mixture of air and fire damp inside the enclosure, with the apparatus in an atmosphere of the same mixture. The enclosure must withstand the pressure of the explosion and the explosion must not be propagated to the outside. This test will be repeated five times.

Ventilated motors shall be kept running for an hour in a current of fire damp and air with candles burning constantly at different points within the enclosure.

There can be no permanent combustion of the fire damp in the interior of the apparatus during the test.

Assembling and Disassembling in the Workings

In underground workings the enclosures of the explosion-proof electrical apparatus can not be opened, disassembled or reassembled except by a person specially authorized by the mine management. This person shall be the sole person permitted to carry the necessary special wrenches. He must supervise the correct assembly, and the fastening of all bolts, screws, nuts, and connection.

The authorized person himself is forbidden to open the enclosure of an apparatus while it is alive, or to make alive an apparatus of which the enclosure is open.

In the program of investigations for 1927, the best way of putting this scheme of regulation into effect is to be determined.

EXPERIMENT STATIONS IN BELGIUM

On August 29, 1927, accompanied by G. Allsop of the British Safety in Mines Research Station and J. A. B. Horsley, H. M. Electrical Inspector of Mines, Great Britain, the writer had the pleasure of visiting the Belgian testing stations at Frameries and Paturage. Frameries has been a noted mine experiment station for a number of years, but in the near future it will be abandoned and all testing work formerly carried on at this station will be conducted close by at Paturage, where there is ample space and where a fine beginning has already been made for a large experiment station.

At the time of the visit the flame-lamp testing gallery, also the gallery in which electric motors are tested, was still at Frameries, and M. Lemaire gave demonstrations with both galleries.

Testing Electrical Equipment

Electrical apparatus is not accepted for test unless it meets the regulations of 1926, already quoted. Drawings are required from the tentative submittor. If these are found to be satisfactory, the equipment can be forwarded for test.

The testing gallery consists of a cubical tank with an opening in the top closed off with paper, and with a glass window for observing the apparatus during tests.

The test procedure is, in general, the same as that set forth in the schedule of 1926. The gas mixtures are made by passing a measured volume of methane into the tank. No analyses are made of the mixture. When making a long test the mixture might become vitiated, so it is changed to offset the effect of the burning of the gas.

The mixture inside the flame-proof compartment is fired by an electric spark. In the case of motors equipped with relief devices, the tests are repeated several times, the motor being allowed to run several hours. If the mixture external to the motor is not ignited by these internal explosions, the motor is judged to have demonstrated its safety. No records are taken of the explosion pressures developed.

CONDITIONS IN BELGIUM AND THE UNITED STATES CONTRASTED

In Belgian mines nearly all of the electrical equipment is of the alternating-current type, whereas in the United States only a small proportion of the underground mining equipment is of that type. The large use of alternating equipment in Belgian mines is probably due to the great depth of the mines (in some cases from three to four thousand feet); if low-voltage, direct-current systems were used a large outlay for copper conductors would be required. By using alternating current the electrical energy can be taken down the shafts at a high potential and transformed inside the mine to a working potential.

In most Belgian mines, because of their great depth, it would be difficult to maintain a roof that would offer satisfactory protection to a trolley locomotive system. Although the haulageways might be arched over with brick or concrete squeezes would undoubtedly occur that would require extensive and frequent repairs. Hence, even if the gas conditions permit, it is not likely that trolley locomotives will ever be used to any large extent in Belgian mines. However, the use of battery locomotives may be considerably extended. Cheaper labor, small cars, and constricted roadways have a tendency to keep back the introduction of mechanical equipment.

If all electrical equipment used in gassy mines is examined and listed in accordance with the specifications of 1926, a high order of safety ought to result as compared with conditions in America, where each of the 30 coal-mining States makes it own regulations and where various degrees of safety prevail depending upon the State law and the strictness of State enforcement officers.

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